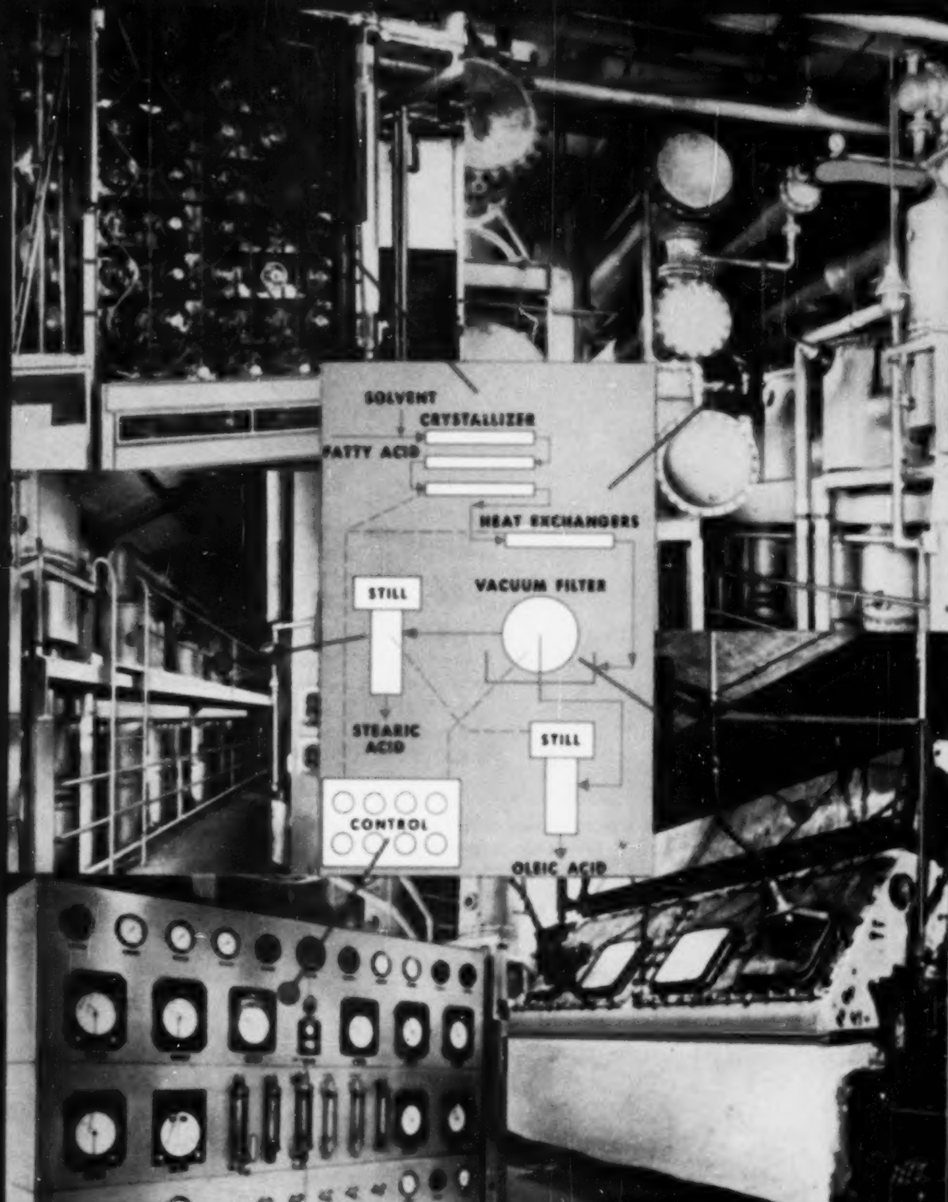
The Spokesman



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NLGI

The INSTITUTE SPOKESMAN

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In This Issue

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Volume XIV Number 12

ABOUT THE COVER

Impurities present in fatty acids, such as iron, dirt and other foreign materials, greatly detract from the quality of finished products made therefrom. These impurities have a catalytic effect on oxidation and produce general deterioration.

To eliminate these harmful impurities and to realize the efficiencies of continuous processes, Emery Industries, Inc. developed the exclusive Emersol Process for separating stearic and oleic acids with the elimination of all types of contamination and manual handling of stocks inherent in out-dated pressing methods.

Illustrated on the cover is a simplified flowsheet of this process and photographs of actual plant equipment. Based on the principles of selective solvent crystallization, the separation of stearic and oleic acid is accomplished effectively, efficiently, and continuously. Built entirely of stainless steel and operating as a closed system, all harmful contamination is eliminated. In addition, automatic controls built into every phase of the operation assure uniformity of products.

There are now several of these units operating continually to meet the varied requirements of the diversified users of all types of fatty acids.

This is another step in the Emery program to provide better fatty acids for better greases.

LUBRICATE FOR SAFETY

- EVERY 1,000 MILES -

President's page

by Howard Cooper, President, N.L.G.I.

STRONGER DEFENSE THROUGH PREVENTIVE MAINTENANCE

It has repeatedly been stated that perhaps the greatest single factor in the military strength of the United States is the ability to produce, quickly and in volume. Nowhere else in the world is the know-how of mass production so fully developed. We who live in the midst of these accomplishments still marvel at the short lapse of time between conception of an idea, and the appearance of a finished product, by thousands and millions, in the hands of consumers, or on remote military fronts.

This capacity to produce war materiel as fast as or faster than it can be utilized is obviously a military advantage of incalculable value. It reflects the inventive skill of machine designers, the experience of plant lay-out experts, and the practical genius of production management. Successful mass production is an achievement of organization and co-ordination, supported by sustained uninterrupted plant operation—24 hours per day for weeks on end, if necessary.

In the modern production plant various departments and manufacturing steps are to a great degree interdependent; schedules of operation in each department are carefully keyed into the pattern of the whole. In some plants the continuity of production may be dependent upon sustained performance of one special key piece of machinery. In any event, the failure or slowing down of one machine in any department may reduce the volume of output. In times of emergency full production is a must; failures cannot be tolerated. Military success and human lives may depend on uninterrupted plant operation. Thus, the extreme importance of intelligent maintenance.

There was a day when maintenance and repairs had the same meaning. Machinery was allowed to run until it broke down; then either temporary or permanent repairs were made, tying up segments of the process, if not the entire plant, and reducing output. This was called maintenance, and many failures were accepted as inevitable.

Today intelligent management puts emphasis on preventive maintenance, the principle of which is "fix it before it needs fixing". Preventive maintenance puts practical meaning into the old adage, "an ounce of prevention is worth more than a pound of cure." Not only is this true in dollars saved in parts and labor; but more important is the avoidance of loss of production time which is infinitely more costly.

The field of preventive maintenance offers to the Lubrication Engineer the most attractive opportunity in his profession, for lubrication is the most important preventive maintenance tool, and the Lubrication Engineer has been trained specifically to use that tool. Systematic application of properly selected lubricants is an acknowledged fundamental of preventive maintenance; for correct lubrication can accomplish more than any other single factor in plant operation to keep machines on the line, producing.

As suppliers of these essentials to effective preventive maintenance, the lubricating grease industry and the lubricating divisions of the oil industry jointly share a responsibility and intense interest in this vital contribution to the defense program.

Plant operators are urged to recognize the full significance and importance of preventive maintenance, and the value of correct lubrication as a means to fend off machine failures and to better assure uninterrupted operation.

Complexes in Lubricating Oil Greases

by **EARL AMOTT**
L. W. McLENNAN
Union Oil Co. of California

INTRODUCTION

The idea that lubricating greases consist of simple, normal soaps in oil is a common one to many people who have had limited contact with such greases. This view is also held by some people who have had intimate contact with this field. It is believed by the authors that much less than half of the lubricating grease produced comes under this classification, i.e. consists of oil thickened with simple normal soap. Most greases contain not normal soaps, but modifications which are hydrated soaps, basic soaps, acid soaps, or soaps stabilized with polar compounds such as salts.

In this paper the authors have chosen to refer to the soap modifications, i.e. hydrated soaps, basic soaps, and soaps associated or combined with various other polar compounds, as complex soaps. It is realized, however, that the term is being used rather loosely to cover association products which may range from chemical compounds on the one hand to possibly association products which are held together by weak physical forces on the other.

Cup greases represent the most common type of grease employing a soap complex as the oil-thickening agent. It was understood long ago that the properties of dry calcium soap dispersed in oil are markedly different from the properties of the corresponding water-stabilized system. This difference was often ascribed to the emulsifying action of water. However, the later view, which it is believed is generally preferred, is that a chemical combination of soap and water occurs yielding a new compound, which has properties different from those of the free soap and free water.[illegible]

Complex aluminum soaps have been employed in lubricating greases for many years. Little or no question exists concerning the point that the aluminum soaps commercially available are basic soaps which have properties quite different from those that the normal soap would be expected to possess and also different from those of aluminum hydroxide or aluminum oxide.

In the preparation of barium soap grease,[illegible] it was found that normal barium soap did not lend itself to grease formation. However, barium soap associated or combined with certain polar compounds, particularly low molecular weight barium salts, was found to be an excellent oil-thickening agent. Again the pattern is evident, that the properties of the complex soap are quite different from those of the normal soap, as well as from those of the stabilizing compound, such as salt in this particular case.[illegible] Again the complex soap is a good oil-thickening agent, whereas the normal soap is a poor thickening agent. This idea has now been broadly exploited on a commercial basis.

The combination of calcium soap with calcium acetate yields a product which has properties quite different from those of the free soap or the free salt, and, in contrast with the normal soaps, it is an excellent grease former.[illegible]

In only a limited number of cases probably is the soap employed in conventional greases as a simple normal soap. Conventional lithium greases and possibly sodium greases which have been heated to high temperatures in their production may fall into this category.

Since a considerable proportion of the industrial lubricating greases are in the class employing complex soaps, a discussion of the subject of soap complexes is considered worthwhile. The object of the following portion of this paper, therefore, is to present information concerning the formulation and properties of these complexes as well as the extent of their occurrence. Also, an opinion concerning the nature of these complexes will be offered.

EXAMPLES OF SOAP COMPLEXES

1. *Lead Soap-Lead Glyceroxide*

Diggs and Campbell[illegible] described the reaction of fish oil with lead oxide obtained by heating these compounds together in a lubricating oil medium. They found that the product of the reaction was not lead soap as anticipated but was what appeared to be a lead soap-lead glyceroxide combination product. Although it was expected that one equiva-

TABLE I

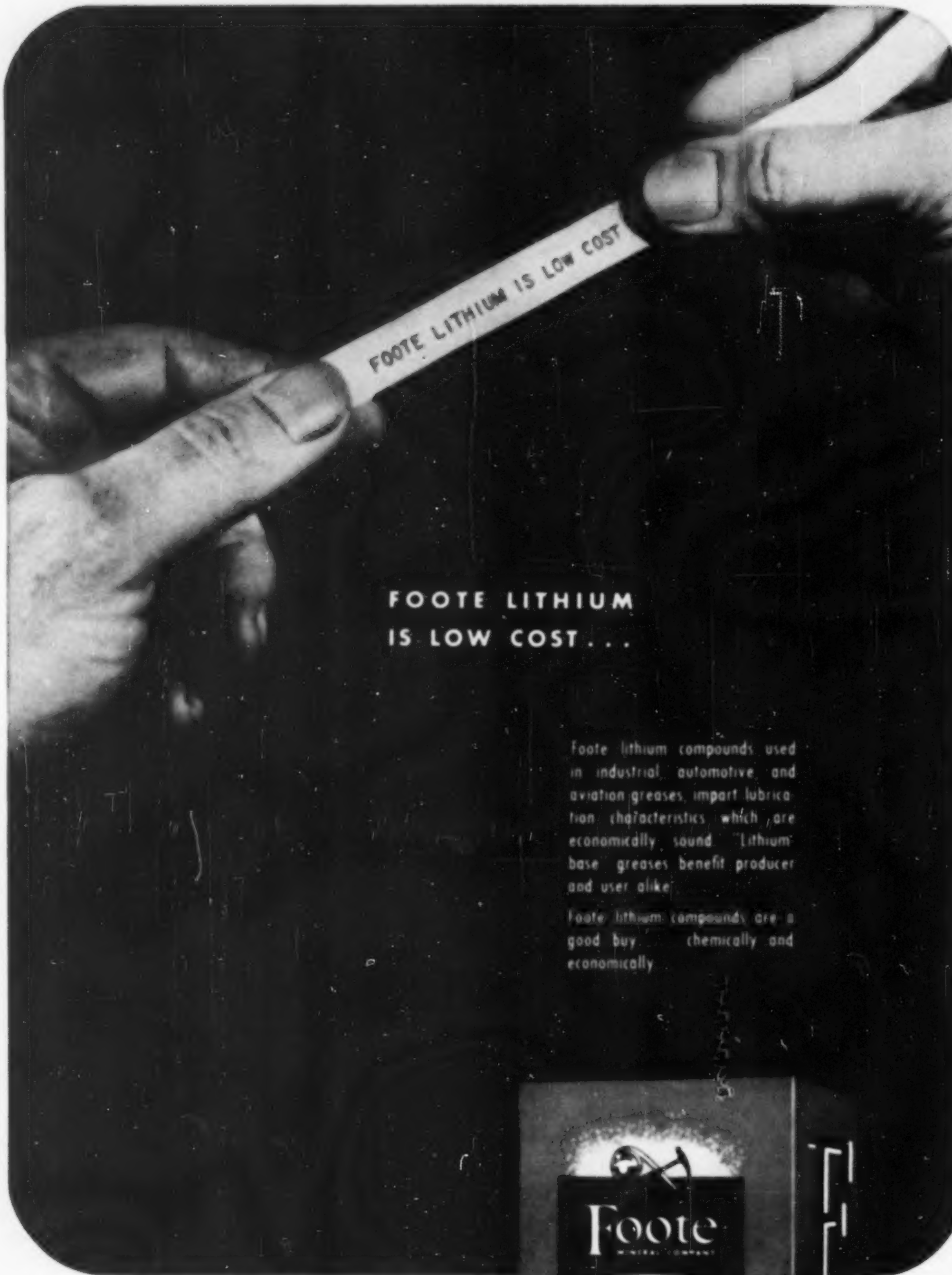
COMPARISON OF BARIUM SOAP IN OIL WITH BARIUM SOAP-BARIUM ACETATE COMPLEX IN OIL

Property	Sample A Barium Oleate in Oil		Sample B Barium Oleate-Barium Acetate in Oil		Anhydrous Barium Acetate	
Composition						
Barium oleate, % by wt.	17		16		none	
Barium acetate, % by wt.	none		3		100	
Oil, % by wt.	83		81		none	
Appearance	soap and oil separated		fibrous, attractive grease			
Penetration, ASTM wkd.	too soft to determine		280			
Dropping point, ASTM, °F.	too soft to determine		over 400			
Electron micrograph[1]	see Figure 1		see Figure 2			
X-ray diffraction pattern[2]	d/n	I	d/n	I	d/n	I
	15.1	MS				
			12.0	W		
	11.1	W				
					9.26	VS
			9.11	VF		
	8.89	M				
	7.40	F				
					6.85	M
	5.55	VF				
	5.07	VF				
	4.50	M	4.46	VF		
					4.38	M
	4.21	W				
			4.12	M		
	3.90	F				
			3.72	MS		
	3.45	VF	3.45	F	3.49	S
					3.36	VS
			3.24	F		
	2.91	VF	2.90	M		
			2.58	W		

1. R.C.A. type EMU 50 K.V. electron microscope was employed. Grease samples were photographed on conventional collodian film mounted on screen. Except where it is noted otherwise, solvent washing and metal shadow-casting were not employed for these samples.

2. The Debye-Scherrer method was employed using a G.E. XDR unit with copper K_α radiation. Oil was removed from Samples A and B by extraction with petroleum ether, and powders were tested giving the results listed.

lent of fat would combine with one equivalent of lead oxide, it was found that only one-half equivalent of fat was consumed for each equivalent of lead oxide. These investigators determined the molecular weight of their reaction product, lead soap-lead glyceroxide, by its freezing point lowering in benzene, obtaining a result of 1603 which corresponds reasonably well with 1554, the theoretical value for the above lead soap-lead glyceroxide formulation. Other observations which were made pointed to the conclusion already noted above, namely, that the reaction product was not a simple lead soap but was a compound in which lead soap and lead glyceroxide were either chemically combined or otherwise closely associated. They pointed out that certain properties of the lead soap-lead glyceroxide product were different from the corresponding properties of the normal lead soap. For example, the former yielded unthickened solutions in lubricating oils while the latter yielded thickened dispersions.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2. *Barium Soap-Barium Acetate*

Several experiments were performed in the authors' laboratory which demonstrated clearly the combination of barium soap and barium acetate to form a complex soap of which the properties are quite different from the properties of either the soap or the salt.

In one instance a suspension of barium oleate in oil was prepared in the conventional manner from barium hydrate, an equivalent amount of oleic acid, and a naphthenic type lubricating oil. For comparison, a corresponding system was prepared from barium hydrate, oleic acid, and oil, but, in addition, three per cent of barium acetate was incorporated into the composition. Detailed information describing the materials and procedures employed is presented in Appendix 1.

These two preparations were markedly different in properties, as is shown by the data in Table 1. In Sample A, barium oleate in oil, there is not an effective dispersion of thickener in oil; on the other hand, in Sample B, barium oleate-barium acetate in oil, there is an effective dispersion. This point is clearly illustrated by the electron micrographs, in which Sample A shows a more or less random dispersion of particles with no fibrous structure whatsoever, whereas Sample B shows a well developed fiber structure characteristic of certain greases. The same conclusion is indicated by the markedly different appearance of these samples and the differences in penetration and dropping point. Sample A shows what would be expected of a poorly dispersed soap-oil slurry, and Sample B is characteristic of a well dispersed grease.

In regard to the x-ray diffraction patterns of these systems, the pattern for Sample A shows that the soap is present as crystals of barium oleate giving the characteristic lines for barium oleate. However, in the case of the pattern for Sample B, some of the prominent lines for barium oleate (Sample A) and for barium acetate as well, are absent. In addition, certain lines are present in the pattern for Sample B which are not found in the pattern for either barium oleate or barium acetate. Apparently the soap and the salt have combined to produce a complex which has unit groupings different from the groupings characteristic of barium oleate or barium acetate, and, which has the unique properties described above.

If the complex in Sample B were simply a physical mixture, it would be expected that salt could be separated from soap by mild physical separation methods. Conversely, if the complex were something more firmly held together, it would be expected that mild physical separation methods would be ineffective. To test this point, Sample C was made identical in composition with Sample B, but with solid barium

TABLE II.

COMPARISON OF BARIUM OLEATE WITH BARIUM OLEATE-BARIUM ACETATE COMPLEX

Property	Sample A Barium Oleate in Oil		Barium Oleate-Barium Acetate in Oil Prepared by Heating in Toluene		Anhydrous Barium Acetate	
X-ray diffraction pattern[1]	d/n	I	d/n	I	d/n	I
	15.1	MS				
			13.4	F+		
	11.1	W				
					9.26	VS
	8.89	M				
	7.40	F				
					6.85	M
	5.55	VF				
	5.07	VF				
	4.50	M				
					4.38	MS
	4.21	W	4.18	W		
	3.90	F	3.93	M—		
			3.72	VF		
	3.45	VF			3.49	S
					3.36	VS
			3.07	VF		
	2.91	VF	2.88	W		
			2.68	VF		

1. Oil was removed from Sample A by petroleum ether extraction and from the above barium oleate-barium acetate sample by acetone extraction, and the powders were tested giving results listed.

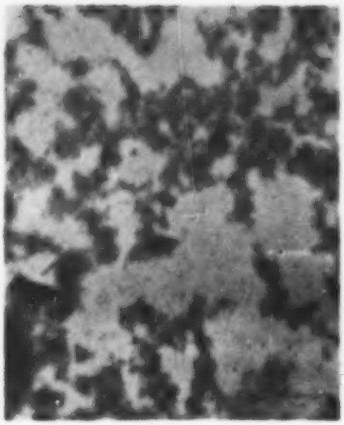

Figure 1
Barium Oleate in Oil

Figure 2
Barium Oleate-Barium Acetate in Oil

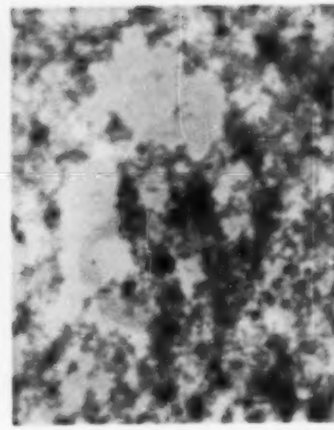

Figure 3
Calcium Oleate in Oil

acetate added to the already prepared soap-oil slurry. Actually, as described in Appendix 1, Sample C was made by intimately mixing three per cent of barium acetate with Sample A, using a mortar and pestle.

When Sample C was diluted with carbon tetrachloride and the suspension centrifuged, essentially all of the salt was deposited, the oil was dissolved, and the soap rose to the top. On the other hand, when Sample B was treated similarly, only a very small amount of salt was deposited, most of it remaining with the soap and rising to the top of the tube. Thus, the soap and salt in the complex could not be separated by this mild separation method, whereas the soap and salt in the physical mixture, Sample C, could be separated.

In order to emphasize further the marked contrast in properties because of the presence or absence of the complex, the following experiment was performed. This experiment clearly demonstrated that a combination of soap and salt occurred to yield a complex having properties different from those of the soap and salt separately:

> 20g. of barium oleate in oil (Sample A) was suspended in 100 ml. of toluene, and the mixture was heated to 230°F. The soap and solvent were present as two separate phases. A small amount of water was added to the system, and immediately the soap dissolved in the solvent. Thus, the hydrated soap, which is considered as one type of complex soap, showed a markedly different solubility in toluene than did the soap itself.
>
> A relatively large amount of saturated solution of barium acetate in water was added to the mixture, and the mixture was refluxed. The combination of salt and hydrated soap gradually took place yielding a salt-containing complex, which was insoluble in toluene, and which settled to the bottom of the toluene phase.
>
> The saturated salt solution was drawn off and dis-

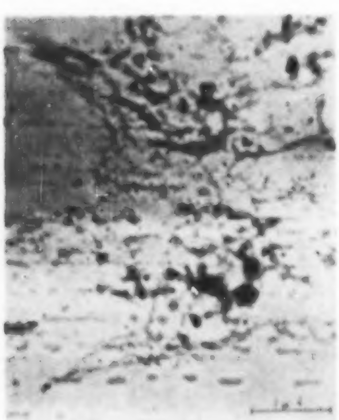

Figure 4
Calcium Oleate-Calcium Acetate in Oil

Figure 5
Calcium Tallowate in Oil

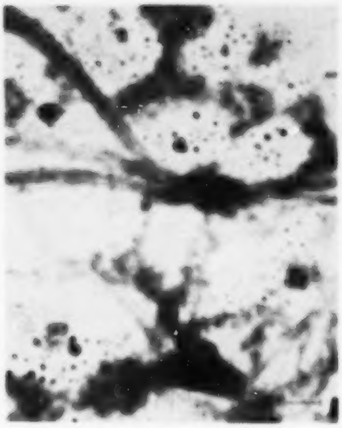

Figure 6
Calcium Tallowate-Calcium Acetate in Oil

Figure 7
Commercial Cup Grease

carded, and the complex and the toluene phases were heated to remove water. In the absence of water, the soap-salt complex was soluble in toluene. The system was filtered, and the toluene was evaporated from the clear filtrate leaving a residue, which was a transparent grease.

In view of the filtration procedure employed in this preparation, it is believed that this sample contained no free salt, i.e. salt not intimately associated with soap. An analysis showed that the composition of this transparent grease was as follows:

	% by Weight	Milliequivalents per gram
Free acid or base	none	none
Barium oleate	16	0.45
Barium acetate	2.7	0.19
Mineral oil	remainder	

Thus, a product was obtained in which approximately one-half equivalent of salt was associated with each equivalent of soap. And, as shown for the other complexes described, the properties of this complex were different from those of the soap or the salt. For example, the x-ray diffraction pattern for this complex, after removal of the oil by acetone extraction, was distinctly different from the patterns for barium oleate and for barium acetate. This is shown by the data in Table II.

3. Calcium Soap-Calcium Acetate

Calcium oleate in oil was prepared in this laboratory in the conventional manner using hydrated lime and oleic acid. A sample of the corresponding system containing approximately five percent of calcium acetate was also prepared. Details concerning preparation of these two samples are given in Appendix 2. As shown by the data in Table III, these products differed considerably in properties, indicating thereby that a soap complex, a combination product of soap and salt, was obtained.

Figure 8
Calcium Tallowate in Oil
(Dehydrated Cup Grease)

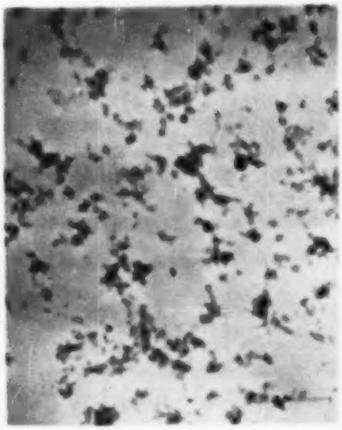

Figure 9
Calcium Tallowate-Calcium Chloride in Oil

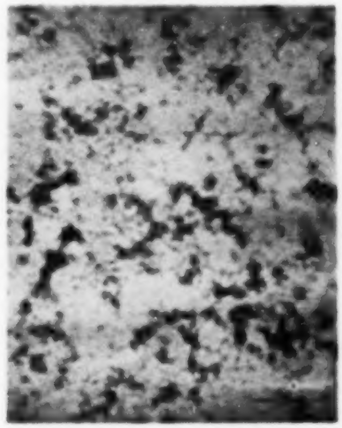

Figure 10
Calcium Tallowate-Calcium Carbonate in Oil

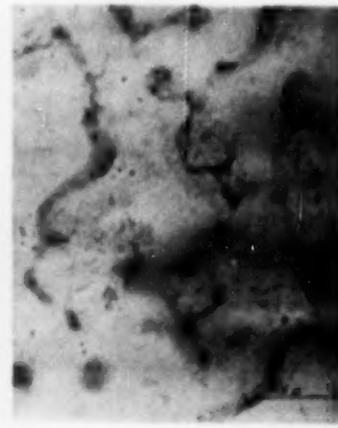

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TABLE III.

COMPARISON OF CALCIUM SOAP IN OIL WITH CALCIUM SOAP-CALCIUM ACETATE COMPLEX IN OIL

Property	Sample D Calcium Oleate in Oil		Sample E Calcium Oleate-Calcium Acetate in Oil		Anhydrous Calcium Acetate	
Composition						
Calcium oleate, % by wt.	17		16		none	
Calcium acetate, % by wt.	none		5		100	
Oil, % by wt.	83		79		none	
Appearance	soap and oil separated		feathery grease			
Penetration, ASTM wkd.	too soft to determine		300			
Dropping point, ASTM, °F.	too soft to determine		over 400			
Solubility of soap in hot benzene	completely soluble		largely insoluble			
Electron micrograph[1]	see Figure 3		see Figure 4			
X-ray diffraction pattern[2]	d/n	I	d/n	I	d/n	I
	15.5	MS				
			11.7	M		
	11.1	F—			11.0	VVS
	9.26	F—				
			8.55	W	8.5	M
			7.45	F		
			6.53	VF		
	4.96	MS (broad halo)	4.91	MS (broad halo)		
	4.48	MS	4.48	M		
			3.88	F		
			3.52	F		
	3.40	M	3.36	W	3.34	S
					3.13	M
	2.95	VF				
			2.87	VF		
			2.75	VVF		
	2.62	W	2.63	F	2.68	MS
			2.43	VF		

1. Conditions described in Table I.
2. Samples D and E were x-rayed without the removal of oil.

In order to furnish further confirmation of the above complex formation, calcium oleate in toluene was refluxed with a relatively large amount of concentrated aqueous solution of calcium acetate. An insoluble complex formed from the soap and salt. Subsequently, the system was dried, filtered, and heated to remove toluene, in the manner previously described for the corresponding barium system. A soft grease of the following composition was obtained:

	% by Weight	Milliequivalents per gram
Free acid	0.6	0.02
Calcium oleate	16	0.53
Calcium acetate	4	0.53
Mineral oil	remainder	

In this sample, which is believed to contain no free salt, i.e. salt not intimately associated with soap, there is one equivalent of salt per equivalent of soap. As shown by the data in Table IV, the x-ray diffraction pattern for this soap complex, separated from the oil by acetone extraction, was markedly different from the patterns for calcium oleate and for calcium acetate.

4. *Calcium Soap-Calcium Chloride*

The modification of soaps by the addition of metal chlorides has been described by *Zimmer* and others.[illegible] In some cases high viscosity concentrates of calcium mahogany sulfonate in oil were combined with calcium chloride to yield solutions of considerably lower viscosity. Several of these systems were described which contained approximately

TABLE IV

COMPARISON OF CALCIUM SOAP WITH CALCIUM SOAP-CALCIUM ACETATE COMPLEX

Property	Sample D Calcium Oleate in Oil		Calcium Oleate-Calcium Acetate in Oil Prepared by Heating in Toluene		Anhydrous Calcium Acetate	
X-ray diffraction pattern[1]	d/n	I	d/n	I	d/n	I
	15.3	VVS				
			12.7	W		
	11.9	MS				
					11.0	VVS
			9.84	M		
	9.42	S				
					8.5	M
			8.23	VF		
	7.93	F				
	6.73	W				
	5.87	M				
	4.44	VVS	4.44	M(halo)		
	4.16	S				
			4.04	F(?)		
	3.40	VS				
			3.34	F	3.34	S
	3.15	VVS	3.17	F	3.13	M
	2.96	W				
	2.68	VVF			2.68	MS
	2.24	VF	2.29	VF		
			2.03	F		
	1.88	F				

1. The oil was removed from Sample D by acetone extraction and from the above calcium oleate-calcium acetate sample by petroleum ether extraction, and the powders were tested yielding the results listed.

one-fourth of an equivalent of calcium chloride per equivalent of soap and which had been filtered and contained no insoluble salt. It was also claimed that the corrosion and detergency characteristics in diesel engine lubricating oils were different depending upon whether they contained normal soap or the soap complex. In another instance, a grease was described which contained approximately 0.05 equivalents of calcium chloride per quivalent of calcium soap. This grease was reported to have a 375°F. dropping point as compared with one of 190-200°F. for the corresponding conventional lime soap greases.

The authors heated a sample of typical commercial cup grease consisting of calcium-tallow soap, approximately one percent of water, and a naphthenic oil with a water solution of calcium chloride to 400°F. Approximately one equivalent of salt was employed per equivalent of soap. The mixture, which was highly fluid at the elevated temperature, was filtered while hot yielding a clear bright filtrate, the properties of which are listed in Table V. Detailed data concerning the preparation of this sample are presented in Appendix 3.

For comparison purposes, a portion of the original cup grease sample was heated to 300°F. to remove the water. In Table V the properties of this material are described as well as those of the cup grease and the soap-chloride complex. The properties of the cup grease were those characteristic of this type of product. Likewise, the properties of the dehydrated grease were those which are typical for systems of this type, i.e. soap and oil were separate phases, and the soap settled rapidly when the mixture was allowed to stand. However, the soap-chloride system was a solution, the viscosity of which was not markedly different over a wide temperature range from the viscosity of the base oil itself. Analysis of the soap-chloride system showed that the product contained essentially all of the soap originally present in the grease along with approximately one equivalent of calcium chloride per equivalent of soap. The solubility of the soap-salt complex in oil at room temperature apparently was markedly greater than the solubility of the soap-water complex or of the soap itself.

Electron micrographs of these three systems are consistent with visual observations. They show that the dehydrated cup grease is a coarse dispersion of soap in oil, the soap agglomerates being irregular in shape, whereas the cup grease

itself is made up of regularly oriented intermeshing fibers in oil. On the other hand, the soap-chloride complex system consists for the most part of very small spherically shaped bodies suspended in oil, with the spheres appearing in general to be separated from each other and relatively independent of each other. From the arrangement of the dispersed phases, it is evident why this system has a viscosity not markedly different from that of the base oil itself and why the cup grease is markedly different.

X-ray diffraction measurements show that the soap in the dehydrated cup grease is present as well-defined calcium tallowate crystals. A similar pattern was obtained for the hydrated soap represented by the cup grease. This is in agreement with the work of Vold et al.[illegible] However, only a broad halo was obtained for the soap-chloride system, showing the absence of crystalline soap or salt.

Most of the foregoing observations suggest that soap and salt in one case and soap and water in the other have become associated to yield products different from the starting materials.

5. *Calcium Soap-Calcium Carbonate*

The modification of soap-oil systems through the use of metal carbonates has been described by McLennan[illegible] and others[illegible]. The general method of preparation described for soap-carbonate complexes consists of heating the soap in oil with base and subsequently neutralizing the system with carbon dioxide. Improved corrosion resistance and detergency have been claimed for diesel engine lubricating oil in which soap-carbonate complex has been substituted for the normal soap. In addition, soap-carbonate greases were described which were desirable, high dropping point products as contrasted with soap-oil slurries usually characteristic of the anhydrous normal soap.

As an illustration of the foregoing type of soap complex, a calcium soap-calcium carbonate system was prepared from a sample of commercial cup grease by mixing the cup grease with a water slurry of lime, heating the mixture to remove most of the water, and neutralizing the base in the mixture with carbon dioxide. Finally the neutralized mixture was filtered yielding a clear, oil-like filtrate.

In Table VI, properties of the soap-carbonate system are compared with the properties of the original cup grease and those of the corresponding anhydrous soap-oil system. As was true in the soap-chloride system described above, the

TABLE V.

COMPARISON OF CALCIUM SOAP IN OIL WITH CALCIUM SOAP-WATER COMPLEX AND CALCIUM SOAP-CALCIUM CHLORIDE COMPLEX

Property	Sample F Commercial Cup Grease		Sample G Calcium-Tallow Soap in Oil		Sample H Calcium-Tallow Soap-Calcium Chloride in Oil	
Composition:						
Free acid, base	nil		nil		nil	
Ca tallowate, % by wt.	10		10		10	
Ca tallowate, milliequivalents per gram	0.34		0.34		0.34	
$CaCl_2$, % by wt.	none		none		2.0	
$CaCl_2$, milliequivalents per gram	none		none		0.36	
Glycerol, % by wt.	approx. 1		approx. 1		approx. 1	
Water, % by wt.	approx. 1		nil		nil	
Mineral oil	remainder		remainder		remainder	
Appearance	buttery grease		separated soap and oil phases		clear, non-thickened solution	
Electron micrograph[1]	see Figure 7		see Figure 8		see Figure 9	
X-ray diffraction pattern[2]	d/n	I	d/n	I	d/n	I
	15.1	S	pattern identical with that of sample F		no diffraction pattern was obtained, only a broad halo of medium intensity with a spread from 4.4 to 5.5 A.	
	11.8	F				
	9.3	W				
	5.81	S halo				
	4.81	S halo				
	4.29	S				
	3.94	F				
	3.18	MS				

1. Conditions described in Table I.

2. Soap-oil systems themselves were x-rayed giving results listed.


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TABLE VI.

COMPARISON OF CALCIUM SOAP IN OIL WITH CALCIUM SOAP-CALCIUM CARBONATE COMPLEX

Property	Sample F Commercial Cup Grease		Sample G Calcium-Tallow Soap in Oil		Sample I Calcium-Tallow Soap-Calcium Carbonate in Oil	
Composition:						
Free acid, base	nil		nil		nil	
Ca tallowate, % by wt.	10		10		10	
Ca tallowate, milliequivalents per gram	0.34		0.34		0.34	
$CaCO_3$, % by wt.	nil		nil		1.8	
$CaCO_3$, milliequivalents per gram	nil		nil		0.37	
Glycerol, % by wt.	approx. 1		approx. 1		approx. 1	
Water, % by wt.	approx. 1		nil		nil	
Mineral oil	remainder		remainder		remainder	
Appearance	buttery grease		separated soap and oil		clear, unthickened solution	
Electron micrograph[1]	see Figure 7		see Figure 8		see Figure 10	
X-ray diffraction pattern[2]	d/n	I	d/n	I	d/n	I
					17.5	S (broad halo)
	15.1	S				
	11.8	F	pattern identical with that of Sample F			
	9.3	W			9.2	F (broad halo)
	5.81	S (halo)				
	4.81	S (halo)				
	4.29	S			4.5	MS (broad halo)
	3.94	F				
	3.38	MS				

1. Conditions described in Table I.
2. Results listed for Samples F and G were obtained by x-raying soap-oil systems themselves, while those for Sample I were obtained by x-raying the powder from which the oil had been separated by acetone extraction.

soap-carbonate complex yielded a clear oil-like solution. Essentially all of the soap originally present in the cup grease remained in the product and carried with it approximately one equivalent of calcium carbonate.

In the electron micrograph of the soap-carbonate complex system, no distant fiber structure characteristic of greases is evident, and no agglomerated soap particles, characteristic of dehydrated cup grease and certain other soap-oil systems, are apparent. This indistinct pattern, along with the highly fluid nature of this system, indicates that the soap-carbonate complex is in a very fine state of dispersion, and that the dispersed particles are not interlocked but they are relatively independent of each other.

From the x-ray diffraction pattern, which consists of several broad halos with no sharp lines, it is evident that calcium soap-calcium carbonate complex contained little or no well-defined crystalline calcium oleate or calcium carbonate. As has been pointed out in connection with the other complex soaps described above, the structural unit in this complex is a unique soap-salt association product, which, under the conditions of the experiment at hand, is not a well-crystallized material.

DISCUSSION

Although only a few examples of complex soaps have been discussed in the foregoing portion of this paper, it appears that the behavior is quite general[5,10,11,15,17,18,19,20,24]. Complexes have been described which were made from soaps of a wide variety of animal and vegetable fats and waxes as well as from higher molecular weight carboxylic acids, acids from the oxidation of various petroleum fractions, rosin, naphthenic acids, sulfonic acids, etc. Also the formation of complexes of these soaps with a wide variety of low molecular weight polar compounds has been disclosed. Among these are salts of low molecular weight organic acids as well as carbonates, chlorides, and others.

The effects of the association of low molecular weight polar compounds with soaps, as described above, are surprisingly varied depending upon the compositions of the materials employed. In some instances soaps which are vir-

tually insoluble in certain solvents are converted into complexes which are very soluble. In other cases, soaps which are soluble in some solvents are converted to complexes which are virtually insoluble. Several specific examples of both types of behavior were described earlier in this paper. It will be recalled that dry barium oleate which is insoluble in toluene becomes soluble when water is added to the system. Upon the introduction of barium acetate, an insoluble complex is formed, which, surprisingly, becomes soluble when water is removed from the system.

A point of much interest, particularly as regards greases, is the freedom from change in aggregation state which many of these complexes enjoy over a wide temperature ran-. Many normal soaps in oil behave as does calcium oleate, i.e. they are essentially insoluble in oil at low temperatures. At higher temperatures, and generally over a rather limited temperature range, they exhibit the limited solubility required for grease formation, and at still higher temperatures they are fluid solutions. In contrast, many soap complexes in oil undergo no apparent changes in aggregation state over a surprisingly large temperature range, i.e. no distinct melting is observed and no other abrupt changes in viscosity are noted as the temperature rises or falls. This property, which is felt to be highly desirable in greases, has prompted most of the investigations which have been carried out in this field.

Furthermore, the soap complexes described, with obvious exceptions in the cases of water-containing complexes, are unusually stable as regards dissociation of soap and salt, or other polar compounds. So far, no evidence of such dissociation has been noted in samples at high or low temperatures with the exception of a calcium soap-calcium carbonate complex, which, on heating in a sealed tube at 600° F. for several hours, showed by the x-ray diffraction method the presence of crystalline calcium carbonate not found previous to the heat treatment. In those instances where the low molecular weight compound combines with water or dissolves in it, the complexes may be destroyed by the water. However, generally, it is physically very difficult to contact the complex with sufficient water to affect the system. Accordingly, these systems have usually been described as water-resistant.

Concerning the nature of the association of soap and low molecular weight polar compound, it is probable that no simple generalization will cover all of the systems under consideration. It is the authors' opinion based upon their work as well as that of others,[1,6,21] that soap-water complexes such as that in cup grease are actually chemical compounds. This opinion is based upon x-ray diffraction and vapor pressure measurements, and upon solubility data. Similarly, in certain other systems the observation has been made, that the amounts of soap and low molecular weight salt or polar compound associating are in simple molecular proportions. This point, it is believed, indicates chemical combination. On the other hand, in many cases the amounts of constituents associating have not appeared to be in simple molecular proportions. This observation, along with the fact that reproducible distinctive x-ray diffraction patterns have not been obtained suggest that the association is an adsorption behavior or a behavior similar to the solubilization of polar compounds described by Harkins[7] and others[9].

CONCLUSION

In conclusion, it is clear from the evidence presented by the authors, along with that published elsewhere by other workers, that soaps are not generally present in greases in a simple form. On the contrary, they exist, in many instances at least, in association with water, salts, or other polar compounds. This idea is of fundamental importance in formulating many greases or in appraising their properties. It is also a consideration of importance in respect to many compounded products, such as may be used for metal cutting purposes, rust protection, or the lubrication of internal combustion engines. Finally, it is believed that the recognition of the existence of such complexes will be helpful in explaining much of the anomalous behavior that is frequently associated with greases, or other compounded products, in their formulation, in their manufacture, and in their use.

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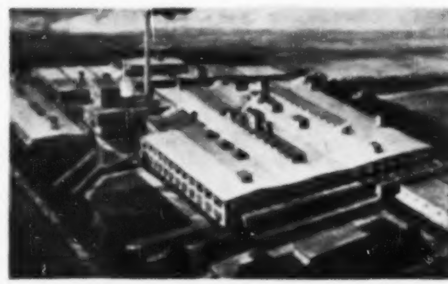

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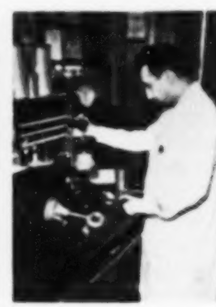

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APPENDIX 1

SAMPLE A—BARIUM OLEATE IN OIL

Materials used:

Barium hydrate, $Ba(OH)_2 \bullet 8H_2O$, Baker's C.P.
Oleic Acid, special light, U.S.P.
Mineral Oil, vis. 600 SUS @ 100° F., V.I.30.

Procedure:

280g. of oleic acid, 153g. of barium hydrate, and 200g. of oil were charged to a kettle and heated to 250°F. while being mixed. An additional 8g. of barium hydrate, and 1540g. of oil were introduced, and the mixture was cooled and worked.

SAMPLE B—BARIUM OLEATE-BARIUM ACETATE IN OIL

Materials used:

Barium hydrate, $Ba(OH)_2 \bullet 8H_2O$, Baker's C.P.
Oleic acid, special light, U.S.P.
Barium acetate, $Ba(C_2H_3O_2)_2 \bullet H_2O$, Baker's C.P.
Mineral oil, vis. 600 SUS @ 100°F., V.I. 30.

Procedure:

280g. of oleic acid, 153g. of barium hydrate, 140g. of oil, and a water solution of 68g. of barium acetate were charged to a kettle and heated while mixing. As the system thickened 1600g. of oil was graded in, and an additional 8g. of barium hydrate was introduced. The mixture was heated to 250°F., cooled, and worked.

SAMPLE C—BARIUM OLEATE-BARIUM ACETATE IN OIL

Materials used:

Barium oleate in oil (Sample A described above).
Barium acetate, $Ba(C_2H_3O_2)_2$, prepared by heating Baker's C.P. $Ba(C_2H_3O_2)_2 \bullet H_2O$ to remove water.

Procedure:

100g. of Sample A was intimately mixed with 3g. of anhydrous barium acetate using a mortar and pestle.

APPENDIX 2

SAMPLE D—CALCIUM OLEATE IN OIL

Materials used:

Calcium oxide, technical grade, lump.
Oleic acid, special light, U.S.P.
Mineral oil, vis. 600 SUS @ 100°F., V.I. 30.

Procedure:

280g. of oleic acid, a water slurry made from 28.5g. of calcium oxide in 75 ml. of water, and 200g. of oil were mixed and heated. An additional 1270g. of oil was added. Mixture was heated to 250°F. then cooled and mixed.

SAMPLE E—CALCIUM OLEATE-CALCIUM ACETATE IN OIL

Materials used:

Sample D above.
Calcium acetate, $Ca(C_2H_3O_2)_2 \bullet H_2O$, Baker's C.P.

Procedure:

500g. of Sample D was mixed with a water solution of 25g. of calcium acetate, and the mixture was heated with agitation to 350°F., after which it was cooled and worked.

APPENDIX 3

SAMPLE F—COMMERCIAL CUP GREASE

Soap content 10%.
Soap identity—calcium-tallow soap.
Oil identity—vis. 200 SUS @ 100°F., V.I. 25.
Method of manufacture—closed kettle saponification.

SAMPLE G—CALCIUM TALLOWATE IN OIL

Materials used:

A portion of the commercial cup grease (Sample F above).

Procedure:

Cup grease was heated to 300°F. and then cooled and mixed.

SAMPLE H—CALCIUM TALLOWATE-CALCIUM CHLORIDE IN OIL

Materials used:

A portion of commercial cup grease (Sample F described above).
Calcium chloride, $CaCl_2$, technical grade.

Procedure:

400g. of cup grease, Sample F, was mixed with a water solution of 7.5g. of $CaCl_2$, and the mixture was heated to 400°F. The mixture was filtered while hot yielding the product, a clear oil-like filtrate.

APPENDIX 4

SAMPLE I—CALCIUM TALLOWATE-CALCIUM CARBONATE IN OIL

Materials used:

Commercial cup grease, (Sample F described above).
Calcium oxide, technical, lump.
Carbon dioxide, commercial.

Procedure:

400g. of commercial cup grease, Sample F, was mixed with a water slurry made from 6.0g. of CaO in 20 ml. of water, and the mixture was heated to 280°F. CO_2 was passed into the mixture until it was no longer alkaline to phenolphthalein. The mixture was cooled, and an additional 4.0g. of CaO in 15 ml. of water added. Again the system was heated to 280°F. and neutralized with CO_2. The neutralized mixture was filtered yielding the product, a clear oil-like filtrate.

GREAS-EVENTS

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Discussion
of
COMPLEXES IN LUBRICATING OIL GREASES

R. A. Swenson
Research Department
Standard Oil Company (Indiana)

I am sure that we all feel that Dr. Amott's paper is very stimulating and interesting. As we look in retrospect into our own grease-making experience I am sure we shall appreciate Dr. Amott's attempt to classify many of the phenomena in terms of the part played by soap complexes and further agree with him that the term must be loosely applied in view of the wide range to be covered.

Dr. Amott and Mr. McLennan have emphasized that greases which they consider as containing complexes are not new. This is undoubtedly true when we consider that additives have been used in grease for many years; perhaps unknowingly at first when the water of neutralization, or reaction, was left in a calcium soap grease in order to obtain a useable lubricant. Later it became common practice to test various materials as additives to modify the chemical and physical characteristics of greases.

There are many common complexes of which we are all aware. One example I would like to cite is the effect of glycerine, or a reaction product of glycerine, in both soda and lime soap greases that undoubtedly is responsible for the differences in characteristics of fat and fatty acid greases. Close control of the glycerine content and the amounts of the saponifying agent are necessary to produce good greases. This is true of both steam kettle and fire kettle products.

It is interesting to note the date of verified discovery of some of the more important soap modifications. Dr. Diggs published the results of his work on lead fish oil soap, an important E. P. additive, in 1928. The Arveson mill grease patent, in which the modified soap is dependent on both composition and method of manufacture, issued in 1932. A Kaufman patent issued in 1935 covers a modified soap formed at high temperatures by saponifying the fat and melting the soap in the presence of a pre-oxidized petroleum oil. The Carmichael, Hain patent describing the calcium soap-calcium acetate modification issued in 1940. This patent, I believe, is of fundamental importance in the field of soap modification with salts of low molecular weight and led to many of the more recent developments in this field. The Earle patents covering lithium soap greases issued in 1942. In practically all of Earle's patents mixed soaps or structure modifying additives are used. Numerous other lithium soap patents covering a variety of formulations and methods of manufacture for producing modified lithium soaps have issued since the Earle patents were first published. The McLennan patents covering the barium soap-barium salt modifications issued in 1947. It is important to observe the extended use of modified soap structures in grease manufacture during the past ten or fifteen years.

As greasemakers all of us know that in addition to the ingredients required in the preparation of any given grease the method of manufacture is also very important. This in itself indicates the complexity of the problem. The formation of the required soap structure is dependent not only on the ingredients present, but on the proper conditions of temperature, time and pressure.

Such factors indicate that extensive work involving chemical and physical studies will be required to elucidate the actual state of the components in a grease and the use of the proper terms to describe such states.

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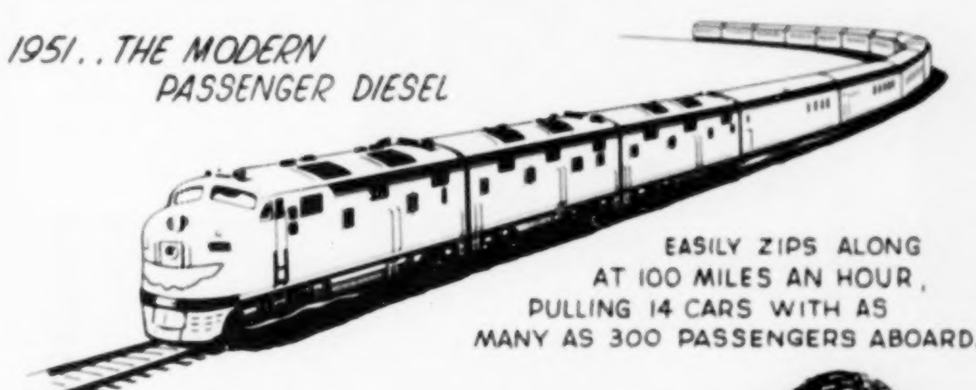

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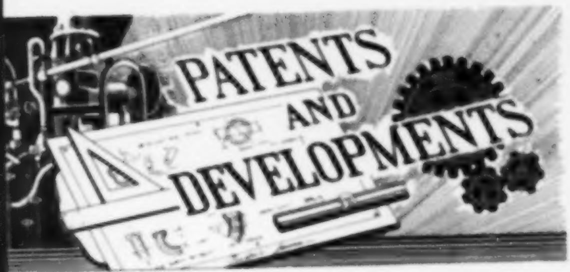

SULFONATE BASE LUBRICATING GREASES

It is well known that lime soap greases have good lubricating characteristics at low temperatures, but are not suitable for use at elevated temperatures such as above 150° or 175° F. Lime soap greases made from fats or fatty acids which have long been used for thickening lubricating oils in the preparation of grease type lubricants, normally require the presence of a small amount of water to insure mechanical stability. In the absence of such water, the soap and lubricating oil separate at the elevated temperatures. This oil separation appears to be due to the evaporation of the water content at the higher temperature, the water normally serving to bond the soap into the oil in some manner and prevent separation in ordinary storage or low temperature use.

In U. S. Patent 2,535,101, Standard Oil Development Company discloses the preparation of suitable lubricating greases by employing an appropriate quantity of a relatively high molecular weight metal sulfonate in combination with a relatively small amount of a lower molecular weight and relatively oil-insoluble metal sulfonate. The invention depends on the fact that a combination of the high and low molecular weight sulfonates dispersed in mineral oil produces a smooth, homogeneous, high melting point lubricating grease which cannot be obtained by the use of either type of sulfonate alone. The grease employing such a combination as a thickening agent is claimed to have a dropping point very substantially higher than in the case of grease, which is thickened with the calcium soaps of fatty acids.

In one example, a lubricating grease was prepared by combining 20 parts by weight on a dry soap basis of oil-soluble calcium petroleum sulfonate having a molecular weight of about 740, with 8 parts by weight of calcium ethane sulfonate with a molecular weight of about 258 and 72 parts of mineral lubricating oil of about 100 S. S. U. viscosity at 100° F. Greases of this type have a good firm consistency as evidenced by a worked penetration of 310, and a high dropping point of 400°F. In general, these grease compositions can make use of the oil-soluble petroleum sulfonates of commerce, which usually contain petroleum sulfonic acids of 300 to 500 or slightly more in molecular weight. The low molecular weight sulfonic acids, such as ethane sulfonic acid, which has a molecular weight of 110, form metallic salts which will not dissolve in oil. Methane sulfonic acid, with a molecular weight of about 96, may be used as well as other homologues. Examples have been submitted to show the use of the calcium, barium and sodium sulfonates, but other sulfonates such as zinc, aluminum, lithium, etc., may be used, and the ratio of high molecular weight sulfonates to the low molecular weight sulfonates is of the order of 1 to 3, the quantity of sulfonate employed depending upon the viscosity of the oil chosen.

In general, the sulfonate proportions will range between 5 and 25% of the high molecular weight compound and 3 to 20% of the low molecular weight material. Additives such as antioxidants, rust inhibitors, tackiness agents, viscosity index improvers and extreme pressure agents may be added.

THE McKEE WORKER-CONSISTOMETER

Two constant-speed drives have been developed at the Bureau of Standards for use with the McKee Worker-Consistometer for mechanically working a fluid and measuring its flow characteristics in the same series of operations. Previously, weights were used to provide various constant loads at which measurements were made of the rate of flow of the material under test. These modifications provide for measurements of the resultant forces when operating at constant rates of flow and permit the determination of the effect of working at various constant rates of shear and also provide for a much greater range of loads. Test data have been submitted showing the effect of mechanical working upon the flow characteristics of some lubricating greases and some raw synthetic rubber.

The results show that the apparatus provides a tool useful in the measurement of the apparent viscosity and the effect of mechanical working for non-Newtonian materials having thixotropic properties. The performance of the apparatus is adequate to cover consistencies of materials ranging from a light lubricating grease to 100 per cent of raw rubber. (McKee et al, Journal of Research, January 1951—Page 18).

GREASING ELECTRIC MOTORS

New electric motors now made by U. S. Electrical Motors, Inc. of Los Angeles have the feature of purging old grease from the bearing when the new grease is forced in. The bearings have 12 times as much lubricant storage space as standard single-width shielded bearings. (Chemical Processing, January 1951—Page 87.)

(Continued on page 34)

Chairman T. G. Roehner, Director of the Technical Service Department, Socony-Vacuum Laboratories

- **N.L.G.I. Grants Fellowship**
- **Leading Scientist to Direct Project**
- **Boner Is New Committee Chairman**

The NLGI Directors, at their January meeting, approved the establishment of a research fellowship at the University of Southern California, along the lines discussed at the November 1, 1950 meeting of the Technical Committee in Chicago and reported in the minutes of that meeting. It will be known as the National Lubricating Grease Institute Fellowship in Colloid Science and it will be under the direction of Dr. Robert D. Vold, Head of the Department of Chemistry of U.S.C. in Los Angeles. Dr. Vold has already made important contributions toward an understanding of the fundamental aspects of the colloid structure of soap-hydrocarbon systems. The stature of those contributions is indicated by the following papers issued during the year 1949.

Characterization of Heavy Metal Soaps by X-Ray Diffraction. R. D. Vold and H. S. Hattiangdi, Ind. Eng. Chem., *41*, 2311 (1949).

Differential Thermal Analysis of Metal Soaps. M. J. Vold, G. S. Hattiangdi, and R. D. Vold, Ind. Eng. Chem., *41*, 2320 (1949).

Crystalline Forms of Anhydrous Calcium Stearate Derivable from Calcium Stearate Monohydrate. M. J. Vold, G. S. Hattiangdi and R. D. Vold, J. Colloid Sci., *4*, 93 1949).

The Phase Study Approach to Grease Problems. M. J. Vold and R. D. Vold, The Institute Spokesman, August 1949, p. 10; reprinted in Canadian Process Industries, December 1949.

A Comparative Study of the X-Ray Diffraction Patterns and Thermal Transitions of Metal Soaps. R. D. Vold and M. J. Vold, J. Am. Oil Chem. Soc., 26, 520 (1949).

The Stability of Sodium Stearate Gels. T. M. Doscher and R. D. Vold, J. Am. Oil Chem. Soc., 26, 515 (1949).

Phase State and Thermal Transitions of Greases. M. J. Vold, G. S. Hattiangdi, and R. D. Vold, Ind. Eng. Chem., *41*, 2539 (1949).

The Phase Behavior of Lithium Stearate in Cetane and in Decalin. M. J. Vold and R. D. Vold, J. Colloid Sci., 5, 1 (1950).

Now that President Howard Cooper has signed the fellowship contract with U.S.C., the assignment of our Research Fellowship Committee has been completed. However, they have agreed to continue with new assignments of handling questions originating from the fellowship and presenting reports thereon to the Technical Committee. The current membership of the Subcommittee is the following.

Mr. L. W. McLennan, Chairman, Union Oil Company of California.

Dr. E. W. Adams, Standard Oil Company (Indiana).

Mr. M. Ehrlich, American Lubricants, Inc.

Mr. Gus Kaufman, The Texas Company.

Mr. H. L. Hemmingway, The Pure Oil Company.

Mr. W. H. Oldacre, D. A. Stuart Oil Co., Ltd.

Mr. T. G. Roehner, Socony-Vacuum Laboratories.

As mentioned at the Chicago meeting, Mr. C. J. Boner has replaced Mr. H. M. Fraser as Chairman of the Subcommittee on the Procurement of Technical Papers for Publication in The Institute Spokesman. The current membership of that Subcommittee is the following.

Mr. C. J. Boner,
c/o Battenfeld Grease & Oil Corporation,
3148 Roanoke Road,
Kansas City 8, Missouri.

Mr. R. S. Barnett,
c/o The Texas Company,
Beacon Laboratories,
Beacon, N. Y.

Mr. C. Malcolm Finlayson,
c/o National Lead Company,
1376 River Avenue,
Pittsburgh 12, Pa.

Mr. H. M. Fraser,
c/o International Lubricant Corporation,
P. O. Box 390,
New Orleans, La.

Mr. J. McGrogan,
c/o Atlantic Refining Company,
Research & Development Department,
2700 Passyunk Avenue,
Philadelphia 1, Pa.

Mr. L. W. McLennan,
c/o Union Oil Company,
Research Laboratory,
Oleum, California.

The addresses of the members are given in order to facilitate contact with them by any one who has a paper which he would like to offer for publication in The Institute Spokesman.

PATENTS AND DEVELOPMENTS

(Continued from page 31)

PHTHALOCYANINE LUBRICATING GREASES

Workers at the U. S. Naval Research Laboratory described a series of phthalocyanine lubricating greases, prepared from silicones, Ucons, petroleums, diesters and halocarbons gelled with 20-30% by weight of phthalocyanine pigment, which are claimed to be stable from —65 to 250°C. The greases show no dropping point below 350°C and remarkable stability with respect to heat and atmospheric oxidation. They also exhibit low bleeding and evaporation rates, are water resistant, and are recommended for applications requiring continuous lubrication for long periods at elevated temperatures, or where relubrication intervals must be extended beyond the time considered safe for storage with conventional soap-gelled greases. (Bibliography of Technical Reports, January 12, 1951—Page 15.)

ISSUED PATENTS

Canadian

470,393 (Our Saviour's Evangelical Lutheran Church)—Grease gun-loading pail bases for grease containers with cutter and interlock means for said containers.

—P. J. GAYLOR

GREASONALITIES

R. E. Mungovan

MUNGOVAN PROMOTED

The appointment of Richard E. "Dick" Mungovan to the position of Southern Regional Sales Manager, with headquarters at New Orleans, has just been announced by Gordon D. Zuck, General Manager of Sales of Inland Steel Container Company.

Mr. Mungovan has been with the Chicago office of the Company since 1939. His broad experience during that time has thoroughly acquainted him with Company policies and products. He started work in the Production Department, later became Manager of the Order Department, and in recent years was a salesman in the Chicago district.

Former Chief Engineer at the Chicago Plant, Thomas M. Dwyer, is named Manager of the New Orleans Plant where he will be in full charge of production.

In line with plans for product development, Norman D. Rice, formerly Manager of the New Orleans Plant, has returned to the home office in Chicago as Chief Engineer in Charge of Research and Development.

LUBRICATE FOR SAFETY EVERY 1000 MILES

PARSONS-PLYMOUTH ENLARGES STAFF

M. W. Parsons-Plymouth, Inc. announces the addition to its staff of Mr. E. B. Twombly, Jr., and Mr. Philip D. Reed, Jr., who will be active in the company in sales promotion as well as in administration as assistants to Mr. Herbert Bye, President.

Mr. Twombly is Mr. Bye's son-in-law and, after army service, was with Chubb and Son for several years. Mr. Reed's previous connection was with Esso Standard Oil Company at Bayway, New Jersey, as a Process Engineer.

They will be associated with Mr. Maxwell D. Smart, at present in charge of the company's Stearate Plant operations, and with Mr. E. C. Schmidt and Mr. John P. Donovan in sales.

Anthony J. Zino, Jr.

SWAN-FINCH PROMOTES ZINO

Mr. Howard C. Moncrieff, President of Swan-Finch Oil Corporation, New York, N. Y., has announced the appointment of Anthony J. Zino, Jr., as Assistant to the President. Mr. Zino was promoted from Sales Promotion Manager and Chief Lubrication Sales Engineer. He is a Past Vice President of the American Society of Lubrication Engineers, and a member of SAE, ASTM, ASM, and American Ordinance Association. Mr. Zino, whose name appears in "Who's Who in Engineering," is the author of numerous articles on lubrication which have appeared in technical publications.

SONNY MAYOR INJURED IN ACCIDENT

H. A. Mayor, Jr., Southwest Grease & Oil Co., was involved in a serious automobile accident in Wichita, Kansas, on February 18. He suffered a broken cheek bone, and bad concussion, and spent the week in the hospital. He will spend the next month or so in a cast which covers his head and leaves him only peep-holes for eyes, nose and mouth. His family, who were with him at the time of the accident, escaped injury completely.

1951 - FUTURE MEETINGS OF YOUR INDUSTRY

MARCH, 1951

20-22 Ohio Petroleum Marketers Assn. (annual convention and marketing exposition), Deshler-Wallick Hotel, Columbus, Ohio.

APRIL, 1951

2-5 The American Socy. of Mechanical Engineers (spring meeting), Atlanta-Biltmore Hotel, Atlanta, Ga.

5-10 National Tank Truck Carriers, Inc. (mid-year meeting), Boca Raton Club, Boca Raton, Fla.

9-10 A.P.I. Lubrication Committee, Detroit, Mich.

10-11 Michigan Petroleum Assn. (annual spring convention), Detroit Leland Hotel, Detroit, Mich.

16-17 A.S.T.M. (Committee D-10 on Shipping Containers), Atlantic City, New Jersey.

16-18 American Socy. of Lubrication Engineers (annual convention and lubrication show), Bellevue-Stratford Hotel, Philadelphia, Pa.

18-20 National Petroleum Assn., Hotel Cleveland, Cleveland, Ohio.

MAY, 1951

7-8 Independent Petroleum Association of America (mid-year directors meeting), Cosmopolitan Hotel, Denver, Colo.

7-10 National Fire Protection Assn., Detroit, Mich.

12-16 National Fire Protection Assn., Montreal, Quebec, Canada.

13-16 American Inst. of Chemical Engineers (regional meeting), Hotel Muehlebach, Kansas City, Mo.

20-22 Empire State Petroleum Assn., Inc., Hotel Statler, Buffalo, N. Y.

21-24 Oil Industry Information Committee, Brown Palace Hotel, Denver, Colo.

28-29 American Petroleum Institute (Division of Marketing, mid-year meeting), Cincinnati, Ohio.

28-June 6 Third World Petroleum Congress, Kurhaus, Scheveningen, Holland.

28-29 A. P. I. Lubrication Committee (with Marketing Committee) Cincinnati, Ohio.

JUNE, 1951

3-8 Socy. of Automotive Engineers, Inc. (summer meeting), French Lick Springs Hotel, French Lick, Ind.

4-6 American Gear Manufacturers Assn. (annual meeting), The Homestead, Hot Springs, Va.

11-15 The American Society of Mechanical Engineers (semi-annual meeting), Royal York Hotel, Toronto, Canada.

18-22 American Socy. for Testing Materials (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

AUGUST, 1951

13-15 Socy. of Automotive Engineers, Inc. (west coast meeting), Olympic Hotel, Seattle, Wash.

SEPTEMBER, 1951

5-8 Oil Industry Information Committee, Waldorf-Astoria Hotel, New York, N. Y.

6-7 Michigan Petroleum Assn. (annual fall convention), Ramona Park Hotel, Harbor Springs, Mich.

11-13 Socy. of Automotive Engineers, Inc. (tractor meeting), Hotel Schroeder, Milwaukee, Wisc.

12-13 A.P.I. Lubrication Committee, Atlantic City, New Jersey.

12-14 National Petroleum Assn., Hotel Traymore, Atlantic City, N. J.

25-28 The American Socy. of Mechanical Engineers (fall meeting), Radisson Hotel, Minneapolis, Minn.

OCTOBER, 1951

13-14 Indiana Independent Petroleum Assn. (fall convention), Hotel Severin, Indianapolis, Ind.

14-20 Oil Progress Week.

NOVEMBER, 1951

3-8 Oil Industry Information Committee, Stevens Hotel, Chicago, Ill.

5-8 American Petroleum Institute (31st annual meeting), Palmer House, Chicago, Ill.

5-8 A. P. I. Lubrication Committee, Chicago, Illinois.

25-30 The American Society of Mechanical Engineers (annual meeting), Atlantic City, N. J.

DECEMBER, 1951

2-5 American Inst. of Chemical Engineers (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

SUPPLIERS OF MATERIALS FOR MANFACTURING LUBRICATING GREASES

Cottonseed Fatty Acids
Tallow Fatty Acids
Stearic & Oleic Acids

A. GROSS & CO.
295 MADISON AVE.
N. Y. 17
FACTORY:
NEWARK,
N. J.

LEAD NAPHTHENATE
(liquid & solid)
LEAD OLEATE
ALUMINUM STEARATE

THE HARSHAW CHEMICAL CO.
1945 East 97th Street, Cleveland 6, Ohio
BRANCHES IN PRINCIPAL CITIES

GREASE MAKERS
ALUMINUM STEARATE
PLYMOUTH
No. 801-22
and all other Metallic Soaps

M. W. Parsons - -
Plymouth, Inc.
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NEW YORK 38, N. Y.

ALUMINUM STEARATE
MORE THAN 30 YEARS OF
CONSTANTLY IMPROVING
QUALITY

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EXTREME JELL
AND
HIGH JELL GRADES

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Synthetic Products Co
LONDON ROAD & EUCLID AVENUE
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STEARIC ACID
OLEIC ACID
RED OIL
FATTY ACIDS

DARLING & COMPANY
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FOR SAFETY
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1000 MILES

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with our
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MANUFACTURERS OF EQUIPMENT FOR APPLICATION OF LUBRICATING GREASES

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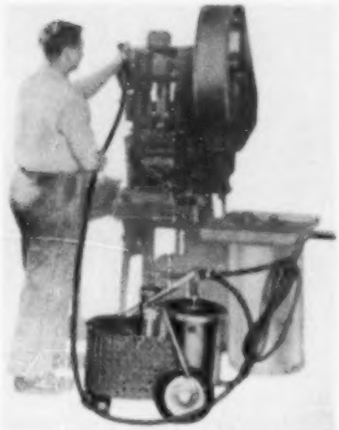

Graco's Lube Service Cart

NEW GREASE RIG

A new Lube Service Cart, for dispensing lubricants to industrial bearings, has just been announced by Gray Company, Inc., of Minneapolis. Compact and highly maneuverable, this two-wheeled grease rig moves rapidly along plant aisles and between closely placed production machines. Since all grease and oil equipment on the rig is removable, even remotely located machines which are inaccessible to the cart can be greased with the cart's equipment.

When stocked with grease and oil for general purpose lubrication (and specialized grease if desired), the Graco Lube Service Cart is a completely self-contained unit requiring no air supply. All equipment is hand operated . . . no air line to connect or electric cord to plug in. High pressure or volume greasing can be done easily, quickly. An oil pump dispenses oil either in single shots or in a steady stream. Because the new cart has such a large capacity, hundreds of bearings can be greased without returning to the lube supply room.

Two models are available. One dispenses grease from a bucket-type unit which holds 30 lbs. of grease. The other pumps from a 25 lb. to 40 lb. refinery filled pail. Each has a 10 ft. high pressure hose with control valve. Both models feature high pressure and volume greasing.

Also included on the cart are an oil pump (in a 2 qt. container) with a 10 ft. dispensing hose and gun; a 1 lb. lever gun, and a ½ pt. Pistol Oiler. Hooks on handle keep hoses off floor. Cart has two 10 in. rubber-tired wheels and a large removable front caster. Front of cart has hinged cover, serves as storage space for tools, adapters, rags and similar needs. Cover makes a convenient seat while greasing low bearings.

For additional information write Gray Company, Inc., 200 Graco Square, Minneapolis 13, Minnesota.

SPOKESMAN BACK ISSUES

Spokesman readers are consistently requesting back issues previous to April, 1948. Just as consistently they have been refused because the stock of issues prior to this date is practically exhausted.

A New Method to Obtain Early Issues

To answer this demand the N.L.G.I. has microfilmed recent issues. It is possible that if sufficient demand is apparent very early issues dating back to its inception in 1937 can be microfilmed and preserved by readers. Volume XIII is completely microfilmed now and Volume XIV should be available shortly after it is bound in April.

If you are interested in obtaining these or early Spokesman issues just write:

UNIVERSITY MICROFILMS
313 N. FIRST STREET
ANN ARBOR, MICHIGAN

SYNTHETIC PRODUCTS JOINS N.L.G.I.

Synthetic Products Company, suppliers of materials for manufacturing lubricating greases, has recently been accepted for membership in the N.L.G.I.

The company was founded in 1917 and at that time they were engaged in the manufacture of rubber compound ingredients. Beginning in 1922, they began supplying the oil and grease industry with metallic soaps. As this industry grew, Synthetic Products Company grew also and today they are pleased to announce that they are now erecting a new plant to meet the increased demand for Aluminum Stearate and other metallic soaps. With this additional capacity, the company expects to at least triple its present production.

"BLACK BONANZA"

The exciting story of one oil company from its start in the earliest Pennsylvania fields through moving to California, experiencing failures, followed by success and still more failures. This is the moving story of Lyman Stewart and how he built the Union Oil Company of California.

It is the drama of a man building a fortune in the early Pennsylvania fields when the only known source of oil was a shallow pool of surface seepage. Back in those days it was called "rock oil" and used primarily for medicinal purposes. Coal oil lamps were yet to be discovered and axles were still lubricated with tallow.

After his fortune disappeared—California and an entirely new search for oil back in the days when the only way to get it was to scoop it out of a surface pool, or tunnel into the side of a mountain. Lyman Stewart drilled hole after hole on untried and unknown structures utterly different from his native Pennsylvania hills. Finally an oil well, then, too much for the existing markets to absorb. After that—development of new products and markets. Clashes of personality; and back in those days they were about as spectacular as the new wells and products they developed.

It's an honest story that pulls no punches. All the mistakes and failures are there and just as honestly told as are the many triumphs. You'll like this true story and enjoy its many illustrations from the earliest oil fields and stills to the latest.

LINCOLN'S AIR RAM ELEVATOR

FORCED INDUCTION PUMP WITH POWER-OPERATED ELEVATOR FOR HEAVY LUBRICANTS AND MATERIALS

For delivery of heavy lubricants, and mastic-materials which will not readily seek their own level, Lincoln Engineering Company, 5702-80 Natural Bridge Avenue, St. Louis 20, Missouri, announces a new hydraulically-operated, single Air Ram Elevator for use with their heavy duty, DeLux air-motor operated drum pumps. The manufacturer claims the unit will exert 7,110 pounds pressure on material and will completely empty and clean sides of 400-pound or 55-gal drums. The unit consists of the Air Ram with three-position control valve for raising, lowering, or holding Pump and Follower Assembly in desired position. Air Regulator with gauge controls air pressure required for forcing pump and follower assembly against material. Solenoid Valve, actuated by micro-switch attached to control valve on material delivery hose, admits air to the pump permitting operation of pump only when material is being delivered. Automatic Follower Vent breaks seal between double-edged sealing member of Follower Assembly and material when Elevator is raised. Built-in chain with toggle clamp holds drum in position on Elevator platform. For complete details, write for Bulletin 678.

EMERY ANNOUNCES POWDERED STEARIC ACIDS

Emery Industries, Inc. announces the availability of all grades of Emersol Stearic Acids in a new powdered form.

Laboratory screen test results for these new powdered Emersol Acids show that 99.5% pass through a U. S. No. 30 sieve (0.0232 inch openings) and 95% through a U. S. No. 100 sieve (0.0059 inch openings).

The company claims that this finer particle size improves performance and increases efficiency.

Properties and Uses: The lubricating properties of powdered stearic acids make them applicable as a mold lubricant and release compound for molding of plastics, rubber, powdered metals, tablets, pellets, etc.

Their affinity for metals facilitates grinding of metallic pigments and powders and is believed to give excellent leafing characteristics to bronze and aluminum pigments. It also makes metal powders oxidation resistant and free flowing.

The fine particle size makes these stearic acids dusting agents. Their polar nature provides a molecular attraction to metal surfaces.

These powdered stearic acids are readily saponified and can be removed with a mild alkali wash. Emersols 130 and 132 are of U.S.P. and N.F. quality and are used in the molding of pharmaceutical tablets, confections and other food products.

METALWORKING LUBRICANTS,

a new book just published by McGraw-Hill, provides a comprehensive and practical coverage of all types of fluids and compounds used to facilitate metalworking processes. The nature, selection and application of lubricants and fluids are thoroughly discussed. Those used in forming non-metallic engineering materials, such as plastics, are also analyzed.

Though it deals primarily with practical shop and plant aspects, this book also includes adequate technical and theoretical explanations of the problems involved in the use of metalworking fluids and lubricants. Illustrations of actual shop operations which demonstrate the various lubricant applications, tabulated data on the properties of lubricants and fluids, and charts containing recommendations for specific applications all make this volume an easy-to-use reference work. They also provide solutions to numerous questions which arise when it comes to selecting and using the right lubricant in the right way for a given operation.

The author, E. L. H. Bastian, discusses all important advances made in the field, among them pretreatment processes, "Hyper-Drilling" with soluble oils, modern rolling oil developments, atmosphere tempering and stress-relief, and grease rolling stability test apparatus. New lubricants such as molybdenum disulphide, chemically active waxes, water-miscible oils for drawing fine-gauge wire, spinning lubricants used for TV tube production, and a variety of synthetic fluids and compounds are all covered in detail.

DEEP ROCK ANNOUNCES NEW OFFICES

Deep Rock announces the opening of new offices in Denver and Sterling, Colorado, to extend the company's land and exploration work in the Rocky Mountain region.

Heading the area office at Denver is W. C. MacQuown, Jr., who received his A.B. and M.S. degrees from the University of Rochester and his Ph.D. in structural geology from Cornell University. In 1946 he accepted a professorship at the University of Kentucky. Other positions have been held with Magnolia Petroleum Company in Dallas, Texas, the Pure Oil Company in Wyoming and the Cooperative Refinery Association.

Kenneth Webb, formerly geologist in Deep Rock's Wichita offices, is now stationed at Sterling.

Castle J. Harvey has been appointed manager of Deep Rock Oil Corporation's geophysical department. Harvey, whose professional career has taken him over most of the United States and Korea, was sent to Korea in 1923 as apprentice mining engineer for the Oriental Consolidated Mining Co. He returned to the States and received his degree from the University of Illinois in 1932. Other positions have been held with the Indiana Highway department, the Geophysical Research Corporation, Amerada Petroleum Corporation's geological department and Atlantic.

R. J. Gaden, who has been administrative assistant in Deep Rock Oil Corporation's marketing division in Chicago, has been transferred to Tulsa as manager of the company's product supply department.

Mr. Gaden's appointment fills the post vacated last fall when A. R. Gockel became assistant to the division manager with responsibility for coordinating supply and distribution functions.

A Deep Rock employee for 24 years, Mr. Gaden has had experience in both the products transportation and marketing fields. At one time he was head of the company's former products supply and distribution department.

F. E. Melott, former area geologist and manager at Midland, Texas, has been transferred to be area geologist in the new office, while J. C. Meyer has been named area geologist, and H. W. Hitt, new area landman at Midland.

Meyer received his B.S. degree in 1941 from the University of Texas. Following four years with the U. S. Air Forces, he returned to the University as instructor in geology. He entered the commercial geology field in 1947 through a position with Barnsdall Oil Company at Midland. In 1950, he transferred to Service Drilling Company where he remained until the Deep Rock appointment.

Hitt began work in 1941 with the Shell Oil Company in Houston, then moved on for short tenures with Ohio and Cities Service oil companies before joining the U. S. Air Forces in 1942. Following his release from service in 1947, he operated his own hardware company in New Mexico for a while, then worked for Seaboard Oil Company before coming to Deep Rock. His experience includes scouting, leasing, claim and title work in the West Texas-New Mexico area.

N.L.G.I. SECRETARY TO SPEAK BEFORE UNIVERSITY

An invitation has just been received by the N.L.G.I. Office for the Executive Secretary, Harry F. Bennetts, to lecture on "Trade Association Publications" before a national group composed of Industrial Publications Editors.

This group of professional journalists is known as The Society of Associated Industrial Editors, who will hold a short course at the Oklahoma A. & M. University from March 12 to 17 at Stillwater, Oklahoma. During the week this course is held, various subjects pertaining to industrial journalism will be presented, such as: editorial content, presentation, writings; art, layout production; external magazines; government relations; and other subjects.

Some of the other lecturers at the course are Indiana Standard's Edward R. Sammis, Editor, THE LAMP; Merritt Whitmer, Director of Publications of Swift & Company; Otto M. Forkert, President of The Chicago Graphic Arts Consultant Organization, and others.

YOUNG CHEMICAL ENGINEERS CAN WIN AWARDS TOO

This year for the first time the Chemical Engineers of Greater New York will present an annual award to an outstanding young chemical engineer in the New York area. This is being established to create a non-monetary recognition for exceptional service to humanity or for outstanding professional achievements.

As most of the existing awards in the fields of engineering and chemistry judge only the magnitude of the achievement, with no consideration of the number of years of effort it involved, the older, more experienced man has a definite advantage. However, real ability abounds among young chemical engineers and the purpose of the new award is to recognize contributions achieved early in the professional career.

The award will be made to a chemical engineer, 32 years of age or under, who has shown outstanding professional ability and service to humanity. Any young chemical engineer working within the geographic area of the society—that is, the New York-New Jersey-Metropolitan area—is eligible. Equal consideration will be given to chemical engineers working in research and development, production, sales, and other fields.

Nominations for the award are invited from all manufacturers, research laboratories, colleges and universities, professional groups, and trade organizations in this area. The sponsoring society is anxious not to miss any qualified candidate for the award. Any individual who wishes to make a nomination may do so by securing an application from Mr. Sidney D. Kirkpatrick, McGraw-Hill Publishing Company, 330 West 42nd Street, New York, New York.

The judges are leaders in the fields of publishing, research, consulting, manufacturing, sales and production. Their wide and varied contacts with chemical engineers in their respective fields qualify them to select the outstanding young chemical engineer of the year.

Members of the judging Committee are as follows:

Sidney D. Kirkpatrick, Chairman of the Board of Judges, McGraw-Hill Publishing Company; Dr. H. B. H. Cooper, Calco Chemical Division, American Cyanamid Company; Zola G. Deutsch, Consultant; Dr. Donald F. Othmer, Polytechnic Institute of Brooklyn; Robert L. Taylor, Manufacturing Chemists Association, Inc.; Dr. Wm. Bowman, Jefferson Chemical Company.

Other members of the board will be announced at a later date. The closing date of the nominations is April 30th, 1951.


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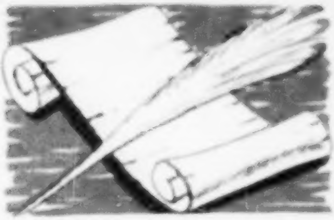
Spline driven rotor assembly simplifies maintenance.
20" x 51" —compact and versatile.
Double-bearing spindle assembly assures positive radial alignment.
Lightweight head is easy to remove.
Model B-1405 available with or without deaerator equipment
Splined drive through flexible coupling eliminates transmission of thrust load to motor.
Polished processing chamber is easy to clean.
EXTRA
USERS REPORT GRATIFYING RESULTS ON LUBRICANTS AND COMPOUNDS.
From plant-proven performance we knew that the new model Morehouse Grease Mill would give spectacular results but reports have exceeded our best expectations. They cover metallic-soap base lubricants, Bentone[1] and Santocel[2] as well as other types. A nationally famous manufacturer writes:
"We have found that it is possible to make Lithium Soap Grease with ordinary grease cooking kettles reaching a maximum temperature of 300° F. The mill allows for the production of a very uniform grease of excellent character."
Get up to 8,000 lbs. per hour, better quality, lower costs. Write today for complete details.
External adjustment to adjust clearance between stones.
More production in a fraction of the space at a fraction of the cost.
Write for complete details today.
MOREHOUSE INDUSTRIES
Originators and sole manufacturers of Morehouse Speedline Equipment
Factory and export sales: 1156 San Fernando Rd., Los Angeles 65
Cable address: "MORESPEED Los Angeles" • Eastern sales: 707 Henry Grady Building, Atlanta 3, Ga.

Associate and Technical Members . . . of the
National Lubricating Grease Institute



Supporting Your Organization These Suppliers of Your Industry Hold Membership in the N. L. G. I.

SUPPLIERS OF MATERIALS FOR MANUFACTURING LUBRICATING GREASES

Archer-Daniels-Midland Co.
(The Werner G. Smith Co. Div.)
2191 West 110th Street
Cleveland 2, Ohio
Member—F. C. Haas

Armour & Co., Chemical Division
1355 West 31st St.
Chicago 9, Illinois
Member—Dale V. Stingley

American Cyanamid Company
30 Rockefeller Plaza
New York City, New York
Member—A. Scharwachter

Darling & Company
4201 South Ashland Avenue
Chicago 9, Illinois
Member—George W. Trainor

E. I. du Pont de Nemours & Company
Wilmington, Delaware
Member—J. R. Sabina

Emery Industries, Inc.
Carew Tower
Cincinnati 2, Ohio
Member—R. F. Brown

Foote Mineral Company
18 W. Chelten Avenue
Philadelphia 44, Pennsylvania
Member—H. C. Meyer, Jr.

A. Gross & Company
295 Madison Avenue
New York City 17, New York
Member—Eugene Adams

W. C. Hardesty Co., Inc.
41 East 42nd Street
New York City, New York
Member—W. G. McLeod

Harshaw Chemical Company
1945 East 97th Street
Cleveland 6, Ohio
Member—G. G. Unkefer

Leffingwell Chemical Company
P. O. Box 191
Whittier, California
Member—D. E. Murphy

Lubrizol Corporation
Euclid Station
Cleveland 17, Ohio
Member—J. H. Baird

Mallinckrodt Chemical Works
New York 8, New York
St. Louis 7, Missouri
Member—C. E. Cosby

N. I. Malmstrom & Company
147 Lombardy Street
Brooklyn 22, New York
Member—Ivar Wm. Malmstrom

Metasap Chemical Corporation
Harrison, New Jersey
Member—O. E. Lohrke

Monsanto Chemical Company
1700 Second Street
St. Louis 4, Missouri
Member—J. W. Newcombe

National Lead Company
105 York Street
Brooklyn 1, New York
Member—Alexander Stewart

National Rosin Oil Products, Inc.
R.K.O. Bldg., Rockefeller Center
New York City, New York
Member—Richard Bender

M. W. Parsons—Plymouth, Inc.
59 Beekman Street
New York City 38, New York
Member—H. Bye

Synthetic Products Company
1636 Wayside
Cleveland, Ohio
Member—G. B. Curtiss

Swift & Company Industrial Oil Division
165th & Indianapolis Blvd.
Hammond, Ind.
Member—F. H. Beneker

Warwick Chemical Company
Division of the Sun Chemical Corporation
10-10 44th Avenue
Long Island City 1, New York
Member—Dr. J. J. Whitfield

Witco Chemical Co.
75 E. Wacker Drive
Chicago, Illinois
Member—R. W. Lewis

CONTAINER MANUFACTURERS

Central Can Company, Inc.
2415 West 19th Street
Chicago, Illinois
Member—Henry Frazin

Continental Can Co.
1103 Waldheim Building
Kansas City 6, Missouri
Member—T. A. Graham

Geuder, Paeschke & Frey Co.
324 North Fifteenth Street
Milwaukee 3, Wisconsin
Member—Willard J. Flint

Inland Steel Container Company
6532 South Menard Avenue
Chicago 38, Illinois
Member—G. D. Zuck

J & L Steel Barrel Company
405 Lexington Ave.
New York 17, New York
Member—Jerry Lyons

National Steel Container Corporation
6700 South LeClaire Avenue
Chicago 38, Illinois
Member—Henry Rudy

Ohio Corrugating Co.
917 Roanoke Ave. So. E.
Warren, Ohio
Member—L. F. McKay

Rheem Manufacturing Company
570 Lexington Avenue
New York, New York
Member—G. Wesley Gates

United States Steel Products Co.
30 Rockefeller Plaza
New York City 20, New York
Member—Wm. I. Hanrahan

Vulcan Stamping & Manufacturing Co.
3000 Madison Street
Bellwood, Illinois
Member—H. B. Scharbach

MANUFACTURERS OF EQUIPMENT FOR APPLICATION OF LUBRICATING GREASES

The Aro Equipment Corporation
Bryan, Ohio
Member—R. W. Morrison

Balcrank, Inc.
Disney near Marburg
Cincinnati 9, Ohio
Member—R. P. Field

Gray Company, Inc.
60 11th Avenue Northeast
Minneapolis 13, Minnesota
Member—L. L. Gray

Lincoln Engineering Company
5730 Natural Bridge Avenue
St. Louis, Missouri
Member—Foster Holmes

National Sales, Inc.
812 North Main Street
Wichita, Kansas
Member—Howard Dearmore

Stewart-Warner Corp.
1826-1852 Diversy Parkway
Chicago, Illinois
Member—Walter Duncan

U. S. Air Compressor Company
5300 Harvard
Cleveland, Ohio
Member—C. A. Benning

LABORATORY EQUIPMENT AND SUPPLIES

Precision Scientific Company
3737 Cortland Street
Chicago 47, Illinois
Member—Alexander I. Newman

SUPPLIERS OF EQUIPMENT FOR MANUFACTURING LUBRICATING GREASES

Buflovak Equipment Division of Blaw-Knox Company
1543 Fillmore Avenue
Buffalo 15, New York
Member—A. W. Johnson

The Girdler Corp.
Louisville 1, Kentucky
Member—John E. Slaughter, Jr.

Morehouse Industries
707 Henry Grady Bldg.
Atlanta, Ga.
Member—George E. Missbach

Stratford Engineering Corporation
1414 Dierks Building
Kansas City, Missouri
Member—J. W. Sylvester

REFINERS

Farmers Union Central Exchange, Inc.
P. O. Box G
St. Paul 1, Minnesota
Member—H. F. Wagner

Freedom Valvoline Oil Co.
Box G
Freedom, Pa.
Member—D. A. Smith

Mid-Continent Petroleum Corporation
Tulsa, Oklahoma
Member—T. E. Fitzgerald

TECHNICAL AND RESEARCH ORGANIZATIONS

Midwest Research Institute
4049 Pennsylvania
Kansas City 2, Missouri
Member—Dr. Geo. E. Ziegler

Petroleum Educational Institute
9020 Melrose Avenue
Los Angeles 46, California
Member—G. A. Zamboni

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